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ABSTRACT

This paper presents the stories of two urban middle school science teachers, both identified as leaders in their districts. Both bring substantial expertise to science education, though neither has experienced optimal conditions for flourishing as teacher leaders. One teacher has strong content knowledge and a deep understanding of standards. The other, who feels that there was never a student she could not reach, received early mentoring and professional development toward a leadership role. The first teacher's greater content knowledge facilitated the implementation of a coherent curriculum. The other teacher's skill in scaffolding instruction produced significant student learning of complex scientific concepts. Neither teacher has yet achieved high levels of expertise in both realms. Their combined experiences highlight the many issues that contribute to the confused state of urban middle school science reform. Inadequate preservice preparation in content, scientific inquiry, and appropriate pedagogical skills leaves new teachers poorly prepared to engage in the complex process required in inquiry-based instruction. There is limited leadership at the district level for providing quality ongoing professional development that integrates content, inquiry strategies, and assessment practices. (Contains 12 references.) (SM)

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Middle School Science: Working in a Confused Context

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Middle School Science Leadership: Working within a Confusing Context

Introduction

This paper presents the stories of two middle grades science teachers from large urban school districts, both identified as "leaders" in their districts. They are part of a two-year study of teacher leaders who have played significant roles in their district and state standards reform efforts. Even with the advice and guidance of science coordinators, principals, and middle school leaders, we found it difficult to identify middle grades science teachers with good classroom practice including an emphasis on inquiry[1], knowledge and experience with a range of different classroom strategies, and an understanding of the national, state and district science standards and their implications for teaching and learning. When we met identified teachers, they sometimes had credibility in the classroom and influence with other colleagues, but rarely were they involved with district policy decisions and reform efforts.

We discovered a few teachers who possessed a deep knowledge of their subject matter and a positive, student-centered interpersonal style, two characteristics that are frequently associated with teacher leadership in other major studies (Medina & St. John, 1997). However, the teachers we met were strong in either one realm or the other, but not both. What's more, science teacher leaders identified for this study, sometimes knew about the science standards and benchmarks,[2] but they were often unable to communicate how to translate the standards into classroom practice. They found it difficult to discuss how curriculum, instructional strategies and assessments could influence their teaching and help students to meet increasingly high standards.

Teachers' lack of science background creates a major obstacle to successful implementation of science standards. Moreover, it decreases greatly the pool of science teacher leaders to lead the reform by working with other teachers who need to transform their teaching so students can learn and do science at more advanced levels. This lack of "identifiable" science leaders reflects the changing, and somewhat confusing, national situation in the science education world. In fact, data indicates that a majority of middle grades science teachers currently lack degrees and certification in science. The American Association for the Advancement of Science (AAAS) reports that 95 percent of the national's largest urban districts have severe shortages of certified science teachers, and 44 percent of teacher education students indicate low interest in becoming science teachers (AAAS, 2000). In grade eight, the Southern Regional Education Board finds that only 11 percent of science classes are taught by teachers who majored in biology, chemistry or physics (Southern Regional Education Board, 2000).

Teacher leaders have to be knowledgeable about the many aspects of the National Science Education Standards (NSES), established by the National Research Council through a comprehensive stakeholder process culminating in 1995. The national standards define the science content that all students should know and be able to do by the end of grades of 4, 8 and 12, and have the potential to impact the assessment of student learning. These rigorous standards have been emulated by states and districts as they designed their own frameworks and standards.

These standards are built around inquiry, as both the content of science and as the process for learning science (NCR, 1996). Therefore, we find broad-based concern not only about teachers' limited subject matter knowledge, but also their limited understanding of inquiry. To use inquiry as a major strategy for helping early adolescents to meet the standards and engage in a process much like the one used by scientists, teachers must understand critical concepts students need to learn. They must also determine the kinds of experiences that will engage students in productive inquiry, mediate children's thinking and reasoning in learning the science concepts and the process of science, and assess their students' achievement. Inquiry-based instruction is a very complex form of instruction, placing considerable demands on teachers (Palinscar, et al. (1999). Again, this is an area often neglected by teacher preparation programs, and given little attention in the professional development offerings by school districts across the nation.

In addition to the importance of teacher preparation and experience, the school district plays a critical role in facilitating or impeding the development of teacher leaders. The National Standards describe very specifically how districts can support teachers in their attempts to guide students to meet a high number of demanding standards. Three particularly important areas highlighted by the standards include: 1) less emphasis on technical, short-term, in-service workshops and more emphasis on ongoing professional development to support teachers; 2) less emphasis on policies unrelated to standards-based reform and more emphasis on policies designed to support changes called for in the standards; and 3) less emphasis on the purchase of textbooks based on traditional topics and more emphasis on the adoption of curriculum aligned with the standards and most importantly, on a conceptual approach to science teaching including support for hands-on science materials (NCR, 1997).

Through our study and the experience of districts around the country, we found a major discrepancy between what standards-based reformers expect from school districts and what actually occurs. In many districts, science still struggles for recognition as a core discipline, as evidenced by the lack of assessments in science. In this era of accountability and high stakes testing, the message to teachers is that what's important is what's tested. As standards-based tests have been developed, the priority in most districts has been literacy and math. While some districts and states are beginning to experiment with science assessments, the focus on science has lagged behind reading, writing, and math.

In terms of professional development and supportive policies, conditions that enable teacher leadership to thrive are largely absent. Teachers rarely work in environments in which they have time and access to participate in support activities and professional interactions with colleagues, time to reflect about their own pedagogy, and time to pursue further study of their subject matter. External supports (e.g., stipends, career ladders and recognition programs) are few and far between. Principal support, coupled with a school culture that both values science as a core subject and provides an overall culture to support reform, is all too rare, and has major implications for the dearth of teacher leaders in science at the middle grades level (Carter & Powell, 1992).

Data from the Third International Mathematics and Science Study (TIMSS) suggested that science curricula and textbooks generally included too many topics; that science curricula and

textbooks were less challenging that in other nations; and that the way teachers organize lessons (as "information transmitters") may be flawed (National Academy of Sciences, 1999). We have learned that most school districts do not generally have well conceived and coherent middle grades science curriculum programs.[3] The Center for Urban Science Education Reform at EDC (Education Development Center) has found there are three categories of curriculum use in the middle grades. Teachers who are teaching out of their content areas, who lack content tend to rely heavily on traditional textbooks. AAAS's recent evaluation of these books indicates that most textbooks cover too many topics and don't develop any of them well. Texts recently reviewed include many classroom activities that are either irrelevant to learning key science ideas or don't help students relate what they doing to the underlying ideas. Dr. George Nelson, Director of AAAS noted that "Our students are lugging home heavy texts full of disconnected facts that neither educate nor motivate them...No matter how 'scientifically accurate' a text may be, if it doesn't provide teachers and students with the right kinds of help in understanding and applying important concepts, then it's not doing its job" (AAAS, 1999).

Teachers who are more experienced and knowledgeable often piece together teacher-developed materials, labs and activities they picked up at conferences and workshops, and readings from different resources. All too frequently this results in programs with an inadequate conceptual base, duplication from grade to grade, and poor sequencing. While district teams often try to align to the standards with instructional materials, this often occurs on a fairly superficial level.

While these situations are characteristic of many middle grades science situations, there are a growing number of standards-based materials that provide opportunities for students to involve students with rich content and engage in both guided and open inquiry experiences. These materials are fairly new, inadequately disseminated, and used by only a small number of middle grade science teachers. These newer materials will help teachers to guide, focus, challenge, and encourage student learning, but will require more faithful implementation. The final group of experienced science teachers who have access to these new curriculum materials seem to be an independent breed, and still selectively choose pieces, loosing some of the conceptual coherence that is built into the program.

Whichever approach they choose, educators have to ensure that the parts that make up the year's curriculum create a coherent whole in which key teaching strategies and expectations for learning reinforce one another from unit to unit. The Center for Urban Science Education Reform recommends that the following characteristics must be present to provide a challenging and coherent standards-based curriculum. It must: 1) integrate science content and process skills; 2) build students' understanding of concepts over time; 3) make connections across different scientific disciplines (earth, life, and physical science); and link science learning to the real world.

Introduction to our Teacher Leaders

We provide the stories of two middle grades teachers as case examples in this paper to illustrate some of the issues just described that inhibit the development of strong teacher leaders in middle school science. While each of these teachers bring substantial expertise to science education, neither one has had the benefit of optimal conditions to flourish as a teacher leader. Samuel Tuttle

and Leann Miller have between them fifteen years of middle grades teaching experience. They are as different as night and day--their teaching experience, subject matter knowledge, and their comfort and competence with students are in stark contrast. However, each has a credibility and respect from their colleagues and peers either at the school or district level, and that credibility has emerged from their classroom experience and their ability to articulate and communicate their views of science instruction at the middle grades. Neither of the teachers works in districts that have a strong shared vision for middle grades science education. And only one of the teachers has the necessary ingredients of a supportive principal and a school culture that values both teacher growth and science as a core academic subject.

Samuel Tuttle: Strong Content Knowledge and a Deep Understanding of Standards

Sam is unique among many teachers we have met due to his knowledge of the science reform efforts at the national level, and in his understanding of the complexities of implementing a standards-based science program at the middle grades. How has he learned about the standards and their implications for teaching and learning? Much like he learned about the business world when he was in the private sector, he reads professional journals and attends seminars and conferences. He keeps updated on developments in science, learns more about inquiry-based instruction, and explores, as time permits, curriculum that is standards-based. Through his own initiative and direction, he grows as a teacher and a teacher leader. Colleagues in the district recognize his knowledge of science and reform, however, administrators have yet to mentor him, support him, or utilize his strengths. Although he is the science department chair and has been invited to serve on a number of district committees, he is confronted with isolation in his department where the three science teachers do not work as a team. As a result, he works as a "lone ranger" and Sam is searching for the right niche for him. Sam is restless to move forward.

Sam describes himself as "one of those people who really wanted to work with test tubes and do something in medicine." This goal led him to teaching science, in a sort of roundabout way. His university physiology course, notorious for being the "weed out" course for medical school, gave him a lot of trouble, so he turned to the university's tutorial program for help. The established tutoring program couldn't help him so he pulled together a group of people from his class together and set up a study group. Judging by the response, Sam had identified a major need and ultimately organizing ten study groups with seven students each to support one another. While this effort did little to help his physiology grade, it led to a job working for the tutoring center for a couple of years as an undergraduate and his eventual decision to look at teaching as a career.

Sam's teaching credential came from the "old system," before the time when most education programs required a bachelor's degree before entering a credential program. His BA in science education required him to do two practicum placements: one observation in an urban high school and student teaching in a more affluent suburban junior high. Most impressive and influential to Sam's development as a teacher was a high school biology class with a wonderful teacher who seemed to get her students to do amazing things. Sam was surprised that students were writing complex science reports. Students were actively engaged in asking questions and conducting investigations -- this was the first time Sam had realized this potential existed. In the junior high the instruction was more teacher-directed -- work sheets, read the chapter, answer the questions

at the end of the chapter. While he preferred the approach he had observed at the high school, the training in his teacher education program was more consistent with the teaching model he encountered at the junior high. However, already he had reservations about this type of pedagogy.

Sam's introduction to teaching was for the most part, trial by fire. He learned to be a problem solver by being thrown into a whole series of difficult situations. His first teaching job in 1985 was at an old urban high school, with the room set up for the traditional stand and deliver teaching with a big experiment desk in the front of the room so he could perform experiments while the students watched. The class was stocked with textbooks, but none more current than 1959. During a period when the district didn't have a curriculum coordinator, the prevailing philosophy was that as professionals, teachers should be free to make the professional decisions. However, his first teaching assignment was chemistry, a course he had never taught, and he was hoping for some guidance. The previous chemistry teacher had effectively killed the chemistry program; in a school of 800 students, only 45 were enrolled in chemistry. His assignment was to rebuild the chemistry program with few guidelines about how to proceed. So, from the very earliest point in his career, Sam was "on his own." He had a challenge, but no tools to take on the challenge.

This experience taught Sam how to scrounge, how to be creative, and how to garner resources he needed to construct a coherent program. A few years earlier the district had developed some learner outcomes for the course, so Sam started with those and worked backwards to build a curriculum. Working more than full time in what was only a half-time teaching assignment, after two years he had succeeded in rebuilding the chemistry program. Due to increased interest, the school now wanted to add another section of chemistry and move him to biology. Just as he was feeling comfortable with the new curriculum, his course was taken away from him and he was asked to start over.

Samuel was bruised and needed to time to deal with a personal setback as well as this professional one. So he retreated to familiar surroundings and worked half time for a year as a study skills specialist back where he had worked as an undergraduate. After a year away, he was ready to go back to the classroom. Declining enrollments and teacher layoffs meant there were few possibilities, so Sam gave the business world a try. He worked for two years, first at a bank, and then for a department store as an analyst. While the hours were better, the challenge and the personal rewards were missing, so Sam decided to join the Peace Corps where he taught biology, chemistry and physics in two rural schools in Kenya.

After a year and a half of substituting and part-time teaching back in the United States, Sam returned to the urban district where he began, this time at a middle school. Once again, Sam found himself in a tough situation. The science classes were mixed grades (sixth, seventh, and eighth) and there was no coherence to the curriculum. There was a revolving theme that changed from year to year, and science was only a semester course at all three grade levels. The two science teachers on either side of his classroom had been feuding for years. He knew he couldn't survive this chaotic situation for long, so during his first year he persuaded the other two science teachers to agree to a science curriculum that was developmental, building skills across three years, which

meant that they would need to separate the grades. Sam found support for his ideas by citing national reports that advocated for more coherence in science education. Project 2061 had just been released and the National Research Council recommendations were in draft form. He followed developments at the national level and was able to use the information to advocate for revising the curriculum. Interestingly, this was a building decision, as there was no district policy about science curriculum, or even the length of the course – a full year versus a semester. Sam based the need to change on the direction advocated by the standards movement. In fact, he saw in the standards movement answers to the questions he had been asking since his first day of teaching – what are my students expected to know and be able to do at the end of this course?

The science standards also validated his philosophy of science education. He used the standards to press for a full year of science and to support an inquiry-based science program. He explained, "I'm using the standards to try and get the best educational program for my kids." Sam uses a lot of cooperative group work and does a lot of project-based learning. It takes considerable time for middle school students to build positive working relationships and learn to manage group work. He felt that it took at least a quarter to get to a point where the groups run smoothly, and then he only has them for another nine weeks before he has to begin the process all over again, socializing the students in the process for learning science. He was also particularly interested in trying to develop thinking skills and logical reasoning among his students, and tried to incorporate skill development in these areas into his lesson plans and projects.

All of these elements can be seen in the following glimpse into his classroom. The lesson was an exploratory exercise examining the rate at which soil and water heat up within a unit on patterns of measurements. The students were also learning to represent data on graphs.

> Sam walked among the tables and consulted with students in a low voice. He asked students to explain their predictions, making sure to hear each student's voice. He was diligent in this process and waited patiently until students responded. The student groups asked each other questions and provided explanations. As they moved to the various stations, Sam continued to visit each group, sometimes prompting students to repeat steps and always asking them to explain what they were doing. Students had to check the temperature every minute and record the readings. As groups began to finish with the measurements, he directed students to return the safety glasses and thermometers. Students returned to their tables and began plotting their results on graphs using colored pencils. The student-to-student interactions gradually increased, with Samuel initiating little of the conversation.
>
> Students needed more assistance when they got to the second part of the assignment. Groups called on him for help, but often caught their own errors when he began to question them about what they were doing. Once Sam noticed that several students were having the same problem, rather than stop and provide direct instruction to the whole class, he made it a point check each table. Most students resolved their own questions with Sam's prodding to focus their thinking. He often asked students, "Why did you do that, or why do you think that happened?" He challenged them by asking, "Are you sure? Could it have been ...? Most students seemed comfortable having conversations with him

about they were doing and thinking. And, in this way, Sam effectively removed himself from the center of the classroom using an inquiry approach to assume the role of "coach."

Sam Tuttle is a ten-year teacher with strong science content knowledge, but by his own admission, someone that finds it a challenge to "connect with the students." In his classroom, it is the intrigue of science that hooks students; it is the range of learning experiences (cooperative groups, independent research, hands-on projects) that often engages them. In classes where students are well behaved, Samuel is at his best, as we observed in this snapshot. When classroom management issues surface, he often finds himself struggling and unable to scaffold instruction in a way that can engage all of the students. When students are focused on their learning, they can meet Sam's high expectations. During the past school year, however, Sam's classes were increasingly diverse and he frequently felt unable to meet the diverse needs of the students, particularly among language minority students. He recognizes this shortcoming, and has turned to the ESL consultant for help.

Sam's classroom is older and minimally decorated, but he has more equipment at his disposal that many science teachers in the district, largely because of his resourcefulness and ability to scrounge. There is wide discrepancy in available resources across the middle grades in the district. Some science teachers are teaching in rooms not designed for science. Some of the newer K-8 schools were built without science rooms, or only one science room for the whole school. Sam finds that there is little communication across the district among science teachers. Some schools have a full year of science; some don't, and teachers are often unaware of what is happening in other schools. The standards movement has probably made some of the inequalities in the district more apparent. Now that there are uniform standards that all middle school students are expected to meet, teachers found that the available resources with which to do that, were often severely limited. Furthermore, the State has developed performance packages in each of the core disciplines, which teachers were asked to pilot in their classrooms. Middle school teachers could choose one of several performance packages to try out and provide the state with feedback and suggestions for their improvement. Many found that there were several that they had to rule out because they did not have the resources. For example, one involves studying an ecosystem. Many of the urban schools do not have access to ponds or wetlands, or other ecosystems within reasonable proximity to their school.

During the period of this study the district had no science textbook adoption, and only a part-time curriculum coordinator for K-12 science. There was no consensus about whether to teach integrated science or separate life science, physical, and earth science units or courses. Lacking direction from the district, and confronted with conflicting orientations within his department, Sam relied on the professional literature for guidance. Early in his career he paid his own way to professional conferences such as NSTA (National Science Teachers Association) and ASCD (Association of Supervision & Curriculum Development) in search of professional learning opportunities to deepen his understanding of the standards movement and to stay current with national trends. He used his knowledge of Project 2061 and the National Research Council's recommendations and his knowledge of pedagogy to select materials that he could adapt to provide a strong foundation in science for his students. Although the recent review of middle school science textbooks by Project 2061 noted that none of the widely used science textbooks

for middle school was rated satisfactory, the series he chose was rated more positively than the others, and was among the best available at the time.

He is selective about the professional development opportunities he attends, opting for training that is consistent with his philosophy of constructivist principles of teaching and learning. He reads the professional literature and explores new software, as it becomes available. In addition, he has been strategic in selecting courses in his graduate program in science education to augment what he is doing in his classroom.

Given the isolation he experienced at his school and the lack of communication across the district, Sam has had to be proactive in pursuing information and learning resources to fulfill his professional needs. Whether he has learned this because of his circumstances or not, Sam acknowledges that his own work preference is individual; he claims he is not a group person. His building administrator described him as less collegial than other leaders in the building, all of whom enjoyed greater consensus among their more like-minded department members. Nonetheless, when a new curriculum consultant for science organized a middle school science leadership team, during the 1998-99 school year, to work on the next textbook adoption, Sam enjoyed participating in this group. It was the only time he actually got to do science with colleagues – try out equipment, run an experiment, and hear other committed teachers' points of view. It gave Sam, perhaps for the first time, colleagues to bounce ideas off of and to reflect with about what is really important for students to know. He noted that through these interactions, he had gained new respect for some of these colleagues.

It was clear that Sam was viewed as a maverick in his building. He has a vision about what a quality program should look like, but he struggled with bringing along his colleagues. Sam was, however, able to command the attention of many of the science leaders in the district. The careful research and thoughtful planning he put into the curriculum in his own classroom demonstrated to others his grasp of the big picture of science standards reform. As with other teacher leaders, the authenticity of his classroom experience was critical to how others viewed his credibility and leadership. Samuel knows that science is more than a collection of facts. While there is a body of knowledge to be learned, his focus is on science as a process, and his goal is to teach students to think like a scientist. He has thought a lot about what is important for students to know, and has worked hard to design curriculum that would lead to that end. And, all of his beliefs are reflected in the organization of his classroom.

Fall 1998 seemed to be a critical juncture in Sam's career. It was a difficult time because the scheduling of electives, especially orchestra and foreign language, tended to exacerbate tracking among the student population. As a result, Sam ended up with a couple of classes with an exceptionally large proportion of special education students, and low achieving students. The experience made him do some serious thinking about whether or not his personality was well suited to work with middle school students. He recognized that he didn't have a very strong connection to his students, and yet he knew that students at this age need adults who are willing to reach out to them. Sam was easily annoyed by having to devote so much time and energy to discipline. Focused on his goals of developing students' appreciation for science and a basic scientific literacy, he often resented the time devoted to arguing with students about what is

acceptable behavior in the classroom. Many educators would posit that strong curriculum and instructional strategies such as cooperative learning are the most effective means of eliminating behavior problems, however, even though Sam has those two pieces in place, he does not have great management skills – perhaps because his rapport with students was as he described, somewhat "standoffish." Acknowledging this limitation, Sam has begun to question whether his skills might be better suited to curriculum development rather than day-to-day classroom teaching.

This soul searching led Sam to examine student outcome data in his course. He found a disturbingly high correlation between students' reading scores and the grades they earned in his class. He began to question whether or not his curriculum was really accessible to lower achieving students. His active involvement on district committees to develop curriculum and performance assessments aligned with his constantly evolving curriculum, resulted in a significant volume of "print-rich" classroom materials. He noticed that second language learners, in particular, struggled in his class. This observation stimulated some serious reflection about his strengths as an educator.

Fortuitously, about this time, an announcement crossed his desk for a half-time research assistant on an NSF-funded project at the university to assist in developing a year-long physical science curriculum for eighth grade. He decided to apply for the two-year position, seeing it as an opportunity to explore possible new career paths in either curriculum development or research, without leaving teaching completely. It seemed like the perfect fit for this juncture in Sam's career development, having reached a level of frustration with the seemingly inevitable conflicts between the day-to-day grind, and having the time for intellectual development, and being able to really think about what he was doing. It was also an expedient way to finish his master's degree in the process.

Sam's experiences illustrate the ways in which a potentially excellent science teacher's opportunities to demonstrate leadership are limited by a lack of district and building support. His district is one where science is still trying to achieve the status of a core discipline. A recent NSF (National Science Foundation) grant obtained by his district may be the catalyst needed to begin to change this situation. For the first time in years there is a full-time coordinator for K-12 science. He is trying to improve communication across the district by bringing together department heads and teacher leaders from each middle school, which may provide the collegial support and professional network that Sam has never had. The district will soon adopt a new curriculum, now that there are better materials available, and Samuel has for the first time, a full year of science in which to develop a coherent program. In addition, the state graduation test may soon include a science portion.

While Sam and Leann share some of the same frustrations, such as a lack of district leadership and coherent curriculum materials to work with, her development as a teacher leader has been nurtured by a strong principal, a professional learning community of dedicated and supportive colleagues, and a curriculum leader who has fostered her professional growth.

Leann Miller: Never a Student She Couldn't Reach

Leann is a young teacher, recently completing her fifth year of classroom teaching. With an undergraduate degree and a wonderful student teaching experience in a reform-minded urban middle school, she was off to a good start. In her classroom, Leann is creative and ingenious in her ability to design lessons that make abstract scientific concepts accessible to sixth grade students. The following introduction to understanding the periodic table illustrates her storytelling ability that enables eleven-year olds to grasp complex ideas.

> The class began a brainstorm about everything that it takes to make chocolate chip cookies. Then using a drawing of a large funnel, she asked the students to order all the items, starting with the largest items down to the smallest items. So they had the oven at the top down to the baking soda, sugar, flour, and salt at the bottom. And then she demonstrated how some of the ingredients, like the baking soda, could be broken down even further. She used this demonstration to segue to the periodic table and explained that this chart lists all the ingredients found in the "science kitchen." Just like your mom keeps things in the cabinets in her kitchen, these are all the ingredients in our science kitchen. She pointed out that the periodic table appeared to be arranged in some sort of order, even though it didn't make a lot of sense to anyone at that point. Their homework that night was to go home and draw the layout of their kitchen, and to label three or four things that were in each of the cabinets. The next day students shared their kitchens with each other and they looked for patterns, cabinets that they had in common. Most people had a cabinet where the pots and pans were kept, a drawer where the silverware was kept, a cabinet where the cereal and dry goods were kept. She then went back to the periodic table and explained that that's how the science kitchen is arranged also; we keep things that have similar characteristics or that we use for the same purpose together in the same cabinet.

The story continued for several days, building on the concepts that students already knew. By the end of the unit, students were able to demonstrate quit sophisticated understanding of the properties of atoms that made up each of the elements. Even without an extensive science background, Leann has been able to do this because she is a life-long learner, and from the beginning she has had a strong connection with kids.

Leann Miller got into teaching on her way to somewhere else. She was getting ready to graduate with a BA in Liberal Studies, with emphases in physical and general science, when she decided to get a credential in order to substitute teach to pay her way through graduate school. After completing her student teaching, she became a long-term sub teaching science and math at a tough, low-income, inner-city middle school through the end of the year. Unexpectedly, she says, "I fell in love with the challenge of it; reaching the kids, seeing the light bulbs go on." She recalls that the challenge was not so much in the content as it was in being able to reach the kids, making a connection with them.

Leann was busy during her first four years. On an emergency credential, she had to go to school part-time, to complete her credential, an experience she found more obligatory than enlightening. She had one good methods class, which was rigorous training in fundamental teaching practices: identifying explicit teaching objectives, checking for understanding, how to do guided practice. She did not find most of her teacher preparation particularly useful, not even methods for teaching science. Much more useful to her were the professional development opportunities provided by her school and the district.

Unlike Samuel, Leann has benefited from almost ideal circumstances. Both her principal and the district's science curriculum leader recognized Leann's potential almost immediately. They mentored her, presented her with professional development opportunities, essentially grooming her for a leadership role. It also helped that Leann's first (and only) regular teaching assignment was at a school where the principal provided strong leadership and had developed a strong professional culture. Teachers shared a unified vision about students' ability to learn, and professional growth opportunities were numerous and encouraged. The principal was an instructional leader who did extensive building-wide training in meaning-making strategies, so that all of the teachers shared a common language. Leann noted, that given all the training they had received, and all the tools they had learned, that there was no excuse for not trying different strategies to reach kids. In addition, teachers had numerous opportunities to attend professional conferences. Leann had already done national conference presentations, and had presented a curriculum unit to colleagues at the district's middle school conference. She had already gained a reputation for her masterful classroom management and her creativity. Moreover, her principal provided substantial opportunities for teachers to work together, both at the department level and as grade level teams. This was a school where teachers like to teach.

In her second year of teaching, Leann was asked to be on a team to develop a GATE (Gifted and Talented Education) program at the school, and had the opportunity to attend several conferences and training programs for working with gifted students. She was also asked to coach the school's Science Olympiad team at her school. During her first summer she participated in a two-week program that promoted a hands-on, integrated approach to science. She also learned from more experienced teachers in her building who were teaching a lab-based science program, which she found more exciting than some of the teacher-directed workshops she had attended. It gave her a vision of the kind of science program she wanted for her students. She became department chair in her third year, and in that role she had greater contact with the district's curriculum leader for science. He sent her to training on performance assessments, preparing her to join the district's science assessment committee. He has also been a primary source of information about professional development opportunities. For example, one summer she became a member of a study team at Lawrence Hall of Science to develop curriculum modules. One spring vacation she spent a week in Baja, California, working with the municipal aquarium and middle and high school science teachers from around the state, to put together marine biology curriculum units. Leann noted that all the staff development opportunities that she has had have been "phenomenal." She believes they have changed the way she works and things. She also credits the teachers she gets to work with [teachers on district committees and at her school site] as a major source of professional learning: "just observing, seeing how they do things, and learning from them."

Perhaps because all the members of her science department had been teaching about the same length of time (they are all relatively young), as department chair Leann did not try to dictate curricular and instructional practices for her colleagues. Rather, she saw her responsibility as chair was to keep the teachers informed of professional development opportunities, and to create occasions that stimulated reflection on whether or not they were teaching the content standards. She did this by periodically reviewing which content standards had been covered to date, which lessons were most effective in addressing those standards, and compiling a resource book of their best lessons. She also asks everyone in the department to keep one copy of all the lessons and assignments they do throughout the year, so that there is a record of progression of their course and the content taught. At the end of the year, they meet as a department and assess the quality of their program and look where the curriculum could benefit from some new ideas. In a district where there is a shortage of supplies and textbooks, one of the most important ways that Leann supports her teachers is to be organized; to be sure that the labs are all in order, that kits are complete with all of the supplies, and that schedules are coordinated to ensure that each teacher has the materials available when they are needed. Although the content standards indicate what students are expected to know at each grade level, there was no textbook or curriculum adoption districtwide. The district had purchased a Prentice-Hall Series, which does not use an inquiry approach, to be used as a resource only. The allocation of texts was limited; there were not even class sets, so the books had to be shared across the department.

As department chair Leann had to learn to be a good listener, and to give people the time they need to process new ideas. Leann's only teaching experience has been within the context of standards reform, and she finds the standards give her confidence that her teaching is very focused. But she recognizes that standards-based teaching requires teachers to work harder. Rather than rely on the favorite lessons they have always taught, teachers now are being asked to teach new content, and to teach it in new ways. Although this is how Leann learned to teach, she understood that it was hard for others to take risks. "You're sticking your neck out, and if it flops it's not exactly a wonderful feeling to see something you've put your time into turn out to be a disappointment." However, she noted that some of the more experienced teachers see the response that Leann gets from her students, both in the quality of work produced, but also in their enthusiasm and interest in science. That example carries a lot of clout in selling her colleagues on standards reform. After only five years, Leann's classroom has become a model for other teachers. She became a new teacher support provider, and other mentor teachers often bring new teachers to her classroom, to observe her pedagogical and management techniques.

Whereas Sam's strength is his depth of content and understanding of the national goals of science reform, Leann's strength is her connection with students. She seems to have a highly refined intuitive sense about what works and what doesn't, as well as the ability to make rapid adjustments to respond to students' learning needs. How did she acquire this ability? She's not sure. She acknowledges that depth of content knowledge is not her strength and she has had to compensate for the gaps in her science background by being an active learner herself. If she doesn't know the content, she is resourceful in finding ways to learn it. She has developed her own standard for ensuring that she has really learned the material: "I know that if I can't make a

real world application with it, then I haven't learned it well enough, and I can't expect my students to be able to learn it."

Year five in teaching was a critical juncture for Leann. She had just completed her credential and began investigating masters programs. But she was already feeling a bit restless, looking for something a bit more challenging, possibly teaching abroad. She found two MA programs she liked: one was local; one was not. She applied to the local program, which was a masters of science and science teaching. She was accepted and the first semester took a meteorology course that was taught on-line. While she enjoyed the course, she was still uneasy about the direction she wanted her career to go. Her principal planted the suggestion that she should get an administrative credential so that she would be eligible to become a principal, which would mean changing graduate programs. Uncertain about what she really wanted to do, she decided to take a semester off from school to do more research and some serious soul-searching. She described the many nights she lay awake wondering, 'If I could have any job I wanted, what would I do?' She finally arrived at the conclusions that she would choose to do just what she was doing. She explained, "I love the kids, I love my classroom."

This period of reflection has made Leann more selective about professional development opportunities. As a young teacher, she was eager to take advantage of every opportunity. She now looks at what the learning pay-off will be, carefully weighing the pluses and minuses of being out of her classroom. She has also enrolled in a two-year on-line Master of Science program, to further develop her content knowledge in science.

Leann is an exceptionally talented teacher in many ways, especially considering her relative inexperience, and yet her inexperience in some areas is apparent. Leann is still developing an understanding of the role that deep content knowledge plays in effective teaching, with the obvious restriction that, "What you don't know, you can't teach." As a member of the science assessment committee for the district she has had the opportunity to participate in the entire process of developing performance assessments: writing, developing rubrics, identifying anchor papers, organizing scoring sessions, training teachers to use rubrics to score papers, and evaluating the entire process. One member of the assessment team is a high school physics teacher, who contributed "amazing" insights that none of the middle school teachers noticed, because she had a much more sophisticated understanding of Newton's three laws of motion. She was able to analyze the prompt and the components of student' responses that met the standard in a way that the middle school teachers could not. Leann recognized from this experience the importance of deep content knowledge and was grateful for the high school teacher's help in teaching her the nuances that she had not previously understood. Leann knows her strength is her pedagogical skills and ability to make the content accessible to students, which she felt was dependent of one's interpersonal skills and the teacher's ability to reach kids. She did not yet make the connection that Shulman (1987) identified, requiring the integration of the two in pedagogical content knowledge.

Furthermore, outside of her graduate work, her professional reading is limited to "what shows up" in her box. She is not yet connected to a state or national network of science teachers or professional science organizations. It was surprising to hear that after only five years of teaching

that she felt she had already exhausted all of the learning opportunities available through her district or state. This may be due in part to the lack of district leadership. The position of science curriculum leader was vacant for eight months, and the teacher who was eventually hired to fill the position was attempting to take on the new responsibilities while continuing to teach part-time. The state had just come out with new state standards, requiring that districts take time out to realign their district standards with the state and national guidelines. In the interim the district sponsored little in the way of science staff development, and there was no connection to the larger state or national context.

Conclusions

Among our two teacher leaders, we found that one teachers' greater content knowledge facilitated the implementation of a coherent curriculum, and the other's skill in scaffolding instruction produced impressive learning of complex scientific concepts among her students. However, neither teacher had yet achieved high levels of expertise in both realms. We found that Sam's teacher leadership was limited by a lack of district leadership, the availability of rigorous districtwide science program, as well as in-depth professional learning opportunities to learn the skills needed in inquiry-based instruction to meet the needs of all students. We found that Leann's connection with students, and her scaffolding of instruction, was exemplary, but she lacked the depth of science understanding and the materials that could provide a coherent science curriculum. As in Sam's case, district leadership was lacking in providing curriculum materials or the professional development needed to ensure the implementation of a rigorous inquiry-based middle grades program. Leann's leadership abilities were identified, nurtured, and supported by a strong principal and a school culture that had professionalism and collegiality as major values. Unfortunately, we found that middle grades science seemed to hold a secondary status in both school districts, struggling for recognition as a core discipline at the middle school level, which limited opportunities for these teacher leaders to gain expertise and a true sense of empowerment—a finding corroborated by interviews with over 50 middle school science teachers and coordinators across the country.[4]

Samuel and Leann bring many strengths to teaching, but they excel in different areas. An example that highlights the different strengths than Sam and Leann bring to teaching science is their perspective on time. They both agree that there is not enough to teach everything they want students to know about science, but Sam's concern was having sufficient time to teach all of the concepts identified in the standards. Leann concurs that there is never enough time to make sure that students understand science concepts and skills in depth. However, Leann's major concern, was a lack of time needed to get to know all of her students, while simultaneously helping her science colleagues to move forward a standards-based agenda.

In the combined experiences of these two teachers we find evidence of many of the issues that contribute to the confused state of science reform at the middle leave in urban districts across the country. Inadequate preparation in both content, scientific inquiry, and appropriate pedagogical skills in teacher education programs leave new teachers poorly prepared to engage in the complex process required in inquiry-based instruction. There is limited leadership at the district level for providing quality ongoing professional

development that integrates content, inquiry strategies, and assessment practices. District policies are often inconsistent in their alignment with and support of the principles of the national science standards. Moreover, support for the adoption and implementation of coherent curriculum materials that will enable teachers to develop a rigorous science program is often lacking. While these policies are needed to assist all teachers in raising the standard of science education, there must also be a strategic district effort to nurture and utilize the talents of potential teacher leaders who will be needed to spearhead these reforms.

NOTES

1. Inquiry has many definitions. National Research Council's, Introducing the National Science Education Standards (Washington, DC: National Academy of Sciences, 1997), 4 explains that inquiry is central to science learning. When engaged in inquiry, students describe objects and events, construct explanations, test those explanations against current scientific thinking, and consider alternative explanations. In this way, students actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills.

2. Both are major documents guiding science education reform. Refer to National Research Council's, National Science Education Standards. (Washington, DC: National Academy Press, 1996) and American Association for the Advancement of Science's Benchmarks for Science Literacy (New York, Oxford University Press, 1993). The AAAS project 2061 provides detailed content standards. The NRC's National Science Education Standards focus on concepts and inquiry, and also identify standards for quality professional development in science, as well as standards for district policies and practices to support the implementation of a standards-based science program. These two sets of standards are complementary and taken together provide comprehensive guidelines for standards-based science education.

3. Members of the Center for Urban Science Education Reform (CUSER) at Education Development Center, Newton, MA have been working with 22 school districts across the country on issues of middle grades science reform. Soon to be published is a middle grades curriculum guide, which will include some of what they learned from practitioners in the 22 communities.

4. This information collected for Education Development Center's Middle Grades Curriculum Guide that will be published in Fall 2000.

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